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ABSTRACT

This basic math skills teaching and learning guide contains practical advice and resources for British vocational teachers who have little formal mathematics education training and for beginning teachers. The document has five sections on these topics dealing with numeracy instruction: (1) overview of the basic skill and its application to other secondary education curricula; (2) two teaching models (discrete and integrated); (3) characteristics of students in application of number classes; (4) teaching techniques; and (5) assessment components. Throughout the guide there are tips, sample exercises, and suggested supplies for teachers to use in the classroom. A glossary of terms and a list of 18 resource organizations are included. Appended are an application of number grid; a list of resources for teaching numbers; a sample task sheet; common calculation difficulties; and mathematics and number websites. (AJ)

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Key Skills
SUPPORT PROGRAMME

ED 473 200

Teaching and learning

Application of Number

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Preface

What is the purpose of this publication?

This *Teaching and learning* guide is designed to provide practical advice and support for teachers who are delivering and assessing the Application of Number key skill at Levels 1 to 3 in schools and colleges. It will be useful as an introduction to the Application of Number key skill, as a source of teaching ideas, for reference, as a handbook, or just for reassurance. The emphasis is firmly on the teaching and learning of the Application of Number key skill and is intended to give practical advice to those working with learners who are developing their underpinning skills in number.

Who is it for?

This publication is written for teachers and lecturers who are asked to teach the Application of Number key skill but who have only limited experience of teaching number and mathematics or key skills. There are two main groups:

- main subject or vocational teachers who have developed their own number skills through everyday life and as part of other courses taken, but who have little or no formal training or qualifications in the teaching of number, and
- mathematics teachers who are used to teaching number skills but who have less experience of teaching the Application of Number key skill.

What is not included?

- Detailed advice and guidance on interpreting the key skills specifications for the purpose of assessing students' work is not included. Assessment is the responsibility of the awarding bodies who provide specialist training (see Appendix 7 for contact details).
- Detailed advice on how to write assignments that develop or provide evidence for key skills is not provided. This is provided in the *Good practice guide: writing assignments*, available from the Key Skills Support Programme.
- Detailed advice and guidance on preparing for the external tests is not included. This is provided in the *Good practice guide: preparing for external assessment*, available from the Key Skills Support Programme.

What you will need

To make full use of this publication, you will need copies of:

- *Key skills units Levels 1–3* (QCA/99/342)
- *The key skills qualifications, specifications and guidance* (QCA/02/896).

Contact details for all the organisations mentioned in this publication can be found in Appendix 7.

SECTION 1

Introduction to Application of Number

What is the Application of Number key skill?

Application of Number (AoN) is the key skill that enables students to select and apply numerical, graphical and related mathematical skills in contexts that are relevant to them, their courses, their work and their everyday lives.

The emphasis is on the *application* of number, but the specifications also place importance on *process* skills. Here are some of the skills required in the specifications:

- identifying and introducing the task or problem
- explaining approaches to the problem
- looking for alternative approaches
- selecting appropriate calculations
- estimating
- carrying out specific calculations
- showing method
- working to appropriate levels of accuracy
- checking
- selecting method of presentation
- presenting findings
- interpreting results
- justifying decisions
- reviewing how the purpose has been met.

It is not just the *doing* that is important here; students are also expected to be able to plan what they are going to do, justify their approach, describe what they have done, explain why they have done it, and then check, interpret, justify and review the results. For students to be successful in this, they really do need to have a good understanding of number.

Why is Application of Number important?

In the curriculum

Most subjects and all vocational areas in the 14–19 curriculum contain some mathematics and use of number. Here are some examples.

- *Art and Design*
  Areas; volumes; ratios of paper size and the golden section; percentages; costings of materials; perspective; measurements.
- *Geography*
  Using maps; interpreting charts and statistical data about different countries; soil analysis; flow rates in rivers.
- *Economics*
  Inflation; handling financial data; handling economic indicators and models; moving averages.
- *Social Sciences*
  Handling statistics; correlation; tests for significance; interpretation of graphs and charts. Number skills are needed in all the social sciences, but in Psychology more than any other.
- *Health and Social Care*
  Interpreting health statistics; temperatures; designing a ward or nursery; weight vs. height graphs; blood-pressure charts before and after exercise.

- *Sciences*
  All the sciences are rich in references to number:
  Physics – equations; measurements (eg distance, speed, time, voltage); area; compound units (eg density, acceleration); work with graphs and charts
  Biology – statistical techniques such as correlation (eg when looking for a relationship between a plant's growth rate and the soil pH); t-tests; working with averages and equations
  Chemistry – moles; reaction equations; measurement of mass and temperature.
- *Leisure and Tourism*
  Statistical data about holiday destinations and preferred leisure pursuits; measurements of length and area calculations when looking at leisure park design.

Teaching tip

Students are often surprised by the mathematical content of degree courses. Ask A-level students to research the number skills required in the degree courses that they are thinking of applying for through UCAS. This may well generate the incentive to study Application of Number with greater enthusiasm.

- *Business courses*
  Company accounts; business plans; analysis of marketing surveys; budgets; sales forecasts; cash flow.
- *PE and Sports Studies*
  Measurement (eg the time of a sprint; distances when marking out pitches or running tracks); equations (eg in calculating ideal body weights).

You will find examples of number appearing in all subjects, at all levels and on all courses in the curriculum. The numerical demands of the courses are usually greater at the higher levels.

Students whose number skills are equal to the demands of their subject or course will achieve higher standards. The Application of Number key skill provides an opportunity to improve students' skills in this area, which can in turn result in an improvement in attendance, attainment, achievement and retention across the institution.

For future employment

The vast majority of jobs in a modern economy – from skilled operatives to middle and senior managers – require the use and application of number skills.

Teaching tip

For vocational groups, ask students to identify a list of job titles that they could apply for at the end of their course. Allocate a job title to each student and set this task:

list the numerical skills that someone with this title is likely to need in the course of their work.

Modern Apprenticeship (MA) frameworks require that Foundation MAs achieve at least Level 1 Application of Number and Advanced MAs achieve at least Level 2, where they do not already have at least GCSE A*–C on entry.

In everyday life

We all use number in everyday life – when out shopping, planning a kitchen, budgeting expenses, checking a payslip, choosing a building-society account, buying a lottery ticket, choosing a mobile phone or planning a holiday. Each of these situations requires us to carry out calculations and base decisions on the results.

The aim of the Application of Number units, at all levels, is to enable students to develop and demonstrate their skills in collecting, interpreting and using information that involves numbers. With this emphasis on the *application* of number, it is essential that teachers ensure, wherever possible, that examples, exercises and assignments are written in a context that has a purpose and a relevance to the students on the course.

Structure and content of the qualifications

In the Application of Number key skill, there are four levels. Level 1 covers the general mathematical skills that might be needed for a student studying for a Foundation GNVQ. It equates to the mathematical skills contained in the National Curriculum Levels 4 and 5. At the other end of the spectrum, Application of Number Level 4 covers the skills that might be needed for a student who is studying for a qualification at Level 4, such as HND or a degree. However, this publication deals only with Levels 1–3.

Components

Each unit is split into three components. Broadly, these can be described as follows:

- obtaining and interpreting information, and planning
- carrying out calculations
- presenting and interpreting results.

These components are intended to be seen as a coherent sequence of stages in any numerical investigation. This is the rationale behind the portfolio requirement at Levels 2 and 3 for a substantial activity that covers all three components.

Differentiating between the levels

As with all key skills, progression through the levels of Application of Number is related to three main strands. As students move up through the levels, they are expected to:

- draw on more complex and a wider range of techniques
- take a more active role in the planning process
- justify the decisions taken and the methods used.

You will need to identify exactly which skills your students need to develop. This will depend on the level that they are working towards. For example, a Level 2 student will need to be able to construct pie charts, while a Level 1 student will not. Figure 1 shows in outline what the requirements are at each level.

Part A of the specifications, showing the underpinning knowledge and techniques for Levels 1 to 3, is reproduced in Appendix 1.

Figure 1 Main differences in requirements between levels

Component	Level 1	Level 2	Level 3
	Candidates must be able to:	**Candidates must be able to carry through a substantial activity that requires them to:**	**Candidates must be able to plan and carry though a substantial and complex activity that requires them to:**
Obtaining and interpreting information, and planning	interpret straightforward information	select information and methods to get the results they need	plan their approach to obtaining and using information, choose appropriate methods for obtaining the results needed and justify their choice
Carrying out calculations	carry out calculations using whole numbers, simple decimals, fractions and percentages to given levels of accuracy	carry out calculations involving two or more steps and numbers of any size, including use of formulae, and check their methods and levels of accuracy	carry out multi-stage calculations, including use of a large data set (over 50 items) and re-arrangement of formulae
Presenting and interpreting results	interpret the results of their calculations and present findings using a chart and diagram.	select ways to present their findings including use of a graph, describe methods and explain results.	justify their choice of presentation methods and explain the results of their calculations.

Links with other qualifications

It is helpful to see how the underpinning skills in the Application of Number key skill relate to other qualifications and curricula that you may be familiar with, eg the Adult Numeracy core curriculum (available from the Basic Skills Agency) and the National Curriculum descriptors for mathematics.

Figure 2 gives a broad indication of these relationships. The link between the Application of Number key skill and the Adult Numeracy core curriculum at Levels 1 and 2 is very close – both lead to exactly the same final test. Other relationships shown give an indication of level, rather than an exact parallel.

More detailed information, including additional guidance and amplification, can be found in* The key skills qualifications specifications and guidance *(QCA/02/896), available from QCA.

Figure 2 Equivalence between the qualifications

Indicative National Curriculum level	National Qualifications Framework	Adult Numeracy	Key skills qualifications
	Level 5		Level 5
	Level 4		Level 4
	Level 3		Level 3
	Level 2	Level 2	Level 2
Level 4/5	Level 1	Level 1	Level 1
Level 3		Entry level 3	
Level 2	Entry level	Entry level 2	
Level 1		Entry level 1	

Assessment

Part A of the key skills specification is the description of the topics and skills that need to be taught and learnt, whereas Part B specifies the portfolio evidence requirements.

- Part A:

  specifies the range of topics
  gives an indication of the depth to which the topics should be studied
  provides a list of topics that might appear in the external assessment (the test)
  is complemented by further guidance to amplify and clarify.

- Part B:

  lays down the minimum requirements for the portfolio assessment
  is complemented by further guidance to amplify and clarify.

There are two components to the formal assessment of the Application of Number key skill.

- *The external test*
  This assesses the student's competence in the underpinning knowledge and skills specified in Part A of the unit. Level 3 external assessments also test the student's ability to apply the underpinning skills in everyday contexts.
- *The portfolio*
  This contains the evidence specified in Part B of the unit. **All** of the requirements in Part B need to be met by the portfolio.

For more details on assessment see Section 5.

Teaching tip

The Adult Numeracy core curriculum provides detailed information at Levels 1 and 2 for key skills teachers, including a wealth of teaching ideas, as well as a more complete breakdown of the curriculum than is given in the key skills specifications.

You will also find lots of help and ideas in the Key stage 3 Numeracy Strategy (see www.standards.dfes.gov.uk/keystage3/strands/?strand=maths).

The importance of teaching and learning Application of Number

- Very few students start their post-16 education – and still fewer their post-14 education – as experts in mathematics. It is sometimes assumed, for example, that 'good' advanced-level students will be competent at working with numbers of all sizes, will be able to carry out a range of multi-stage calculations accurately and will be able to present findings effectively. However, the experience of many teachers, and a growing body of evidence, suggests that this is not true; even where students do possess the skills, they are often unable to transfer those skills and apply them in a practical context.
- The skills that students do not yet have, and those in which they might improve, need to be taught and learned (for further details on diagnostic assessment, see Section 3). The skills that students already have need to be developed further and applied in relevant and practical contexts. Figure 3 (see page 9) shows a model of progression – from being taught the underpinning skills, through practising the skills in context, guided by the teacher, to a demonstration of those skills in context as an independent learner. (The key skills continuum is revisited in Section 4.)
- Students who have been taught the underpinning skills, and who have had an opportunity to practise and use those skills in a variety of contexts before being assessed, are more successful both in putting together a portfolio and in external tests. In turn, perhaps unsurprisingly, this leads to improved performance in other areas of work.

Teaching number – a challenge

The Application of Number key skill emphasises the word 'application' and so it would seem to be perfectly natural for you to design a scheme of work that is driven by the application rather than by the number. For example, in a Foundation Business GNVQ, each number skill would be covered as and when it arises through the business units themselves. This approach is often followed when the delivery is through an integrated model (more details of this approach are given in Section 2 on page 10), but although it has many advantages, it has some disadvantages too.

Teaching tip

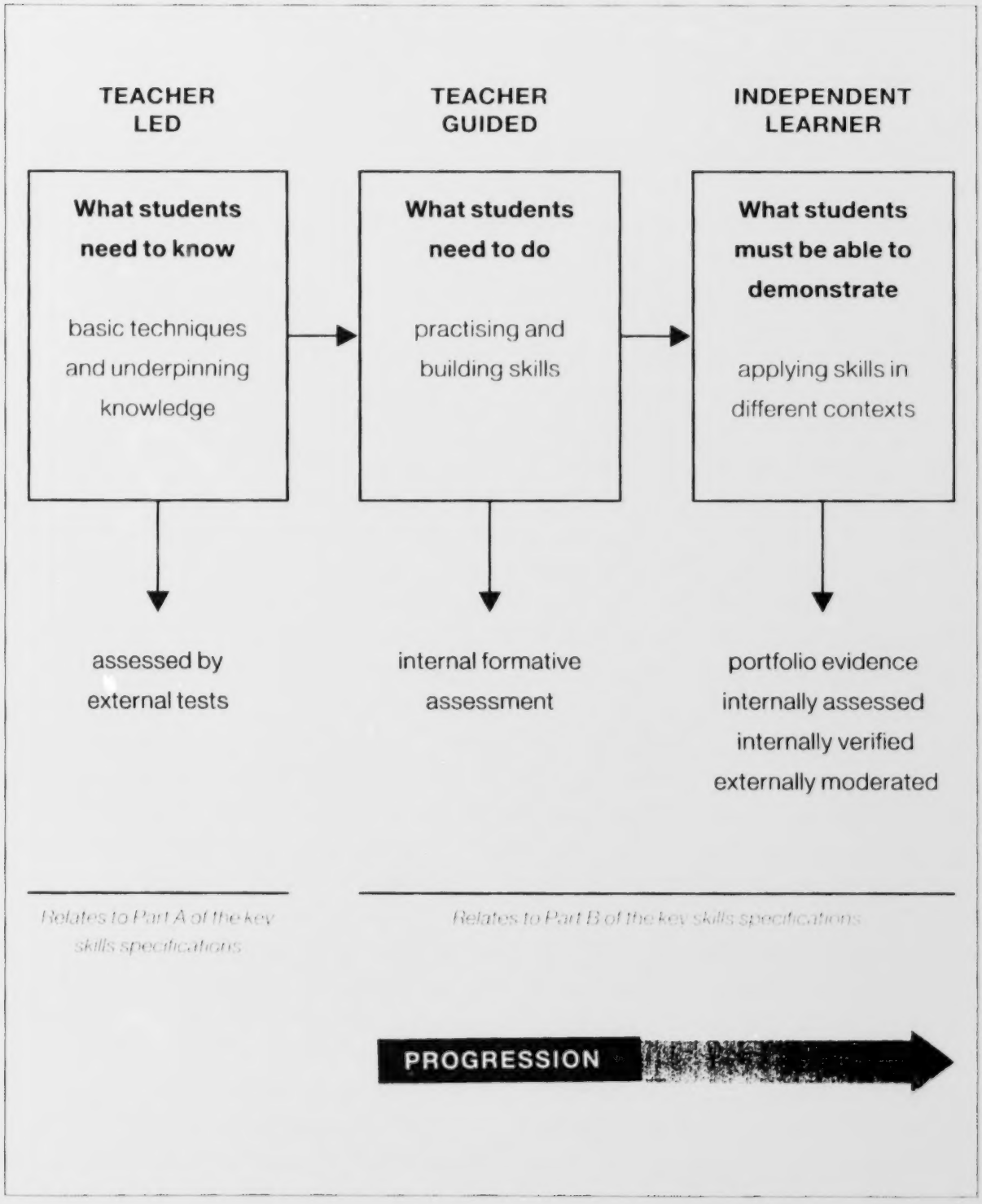
Ask your students what their interests and hobbies are. Many will involve the use of numbers (eg football league tables, darts, snooker, athletics, breeding reptiles, foreign travel). This will provide you with a range of contexts that are of interest to your students and that you can use in the lessons.

Number skills sit in a hierarchy and many are sequential. This means that, as number teachers, we have to look at the number topic we are teaching, identify the skills that are its essential prerequisites, and ensure that these skills are understood before the topic in question is begun. This governs the order in which we can tackle topics and so dictates the shape of the scheme of work. For example, at Level 2, a student will need to know how to multiply and divide numbers (without a calculator) before embarking on problems involving percentages. Similarly, students will need to be able to work confidently with decimals before being able to measure a room and calculate its area or volume.

There is therefore a tension – even a contradiction – between best practice in teaching mathematics (ie following a sequence of number skills) and best practice in teaching Application of Number in context (ie on an 'as needed' basis). With the former, there is the risk that students will see the Application of Number work as irrelevant. With the latter, there is the risk that students will try to perform calculations while still lacking some prior number skill.

It is helpful to be aware of this tension when planning and delivering Application of Number.

Figure 3 A continuum of key skills development



SECTION 2

Where are you with Application of Number?

Teachers and delivery models

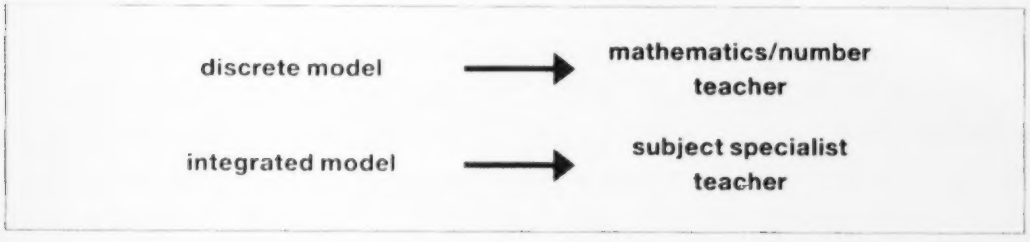
A teacher of Application of Number is typically either:

- a mathematics or number specialist, or
- a subject specialist with responsibility for delivering Application of Number in the context of the subject.

Similarly, while there are many ways of delivering Application of Number, all are essentially based on just two models:

- the discrete model
- the integrated model.

In broad terms, the two types of teacher relate to the two main models.



The discrete model

In this model, Application of Number is delivered in specially timetabled lessons that are taught by a mathematics or number specialist.

Advantages

As a mathematics or number specialist, you will :

- have experience of teaching the underpinning knowledge. Application of Number has much in common with the National Curriculum and the GCSE in Mathematics
- already have a range of teaching techniques to help students understand the required concepts
- already have access to plenty of well-graduated worksheets that will help students practise the skills learnt
- know the best order in which to arrange the scheme of work so that the programme of work is coherent and appropriate
- be able to provide an effective context in which to prepare students for the external test.

Challenges

- You will need to liaise effectively with vocational and subject teachers to ensure that students are given opportunities to develop their skills and work on assignments that are relevant and useful to their main programme.

  This is a particular challenge on A-level courses, where students study a mix of subjects. Some institutions deal with this by grouping students in Application of Number classes so that they are studying broadly similar A-level subjects.

On vocational courses, you will need to familiarise yourself with the range of courses that the students are following. For example, if you are teaching students who are studying for an AVCE in Art and Design, you will need to liaise with colleagues in the Art department to establish where number is used in Art. You may have to develop worksheets that enable students to practise number skills in the context of Art and Design (eg ceramic mixes, paper sizes, architectural plans, the golden section, art-gallery attendance statistics).

- You will need to work closely with vocational and subject teachers in planning assignments. (Additional help on this topic is available in the *Good practice guide: writing assignments*, available from the Key Skills Support Programme.) The most successful key skills courses are those that use assignments incorporating work generated in the students' main subjects. This might necessitate liaising with other teachers and working with them, for example to write assignments that incorporate number in a vocational unit, or to adapt an existing assignment so that it meets the Application of Number criteria.
- You will need to ensure that the links with the vocational or subject areas are so close that students perceive Application of Number as an integral part of their course. If they perceive it as peripheral, students may lose interest, which will affect their results.
- You will need to clarify issues of responsibility for the setting and marking of the portfolio work. Colleagues will need to be given clear guidance on their roles.

The integrated model

In this model, Application of Number is integrated into the main course of study and is taught by a subject specialist. On some courses, Application of Number is integrated into one or perhaps two units. For example, on a Business GNVQ it might be integrated into a marketing unit and an accountancy unit. On an A-level programme, it might be integrated into Psychology, Geography, Sociology or the sciences.

Advantages

- Skills development and the portfolio work occur naturally as part of the assignment programme and students tend to take Application of Number more seriously. Indeed, in many cases they don't see it as a separate subject at all; it has become just another topic in the programme and on a par with other units and topics. This advantage should not be underestimated.
- Many students may have had bad experiences in mathematics, and this fresh, applied approach can overcome many of the problems students have in revisiting topics that they feel they have 'done before' and perhaps not enjoyed.
- The application of the skills is clearly emphasised. Everything that is done has an obvious and useful purpose in a context that is relevant to the course of study.
- Your AoN students are studying for a qualification in your specialist area. You will be able to identify and create opportunities for them to develop their number skills in relevant and practical contexts. This will be particularly useful when planning the assignment programme for generating work for the portfolio.

- You may teach the same students in their main programme. This will enable you to establish and reinforce the links between the Application of Number key skill and the rest of the course.

Challenges

- The scheme of work is driven by the main course, not by the sequential requirements of mathematics teaching. As was mentioned in Section 1 (page 8), specific skills in mathematics are often best learned sequentially, because so many of the higher-order skills depend on a sound knowledge of other skills. This hierarchy needs to be understood in order to design a coherent programme of work. Teachers have to find ways to cover number topics coherently; there may be a tendency for teachers to resort to rote methods rather than the teaching of sound mathematical concepts and thinking.
- Students may see number as 'belonging' to only one subject or unit. This can lead to problems in developing number as a transferable skill. Students need to learn to transfer their number skills from one context to another. They will meet the same type of number problems in a range of different settings and situations. For example, percentages are used in VAT, savings, mortgages, pay calculations, and shopping, as well as appearing in vocational or subject settings. Teaching number concepts outside specific contexts not only makes the understanding more straightforward, it also makes it easier to transfer the skill to a range of contexts.
- As with any other skill, mathematics needs practice. Most mathematics courses involve working through a series of graduated but similar examples – similar to practising scales in music! You will need to take care not to overlook this aspect of number teaching in this model, and ensure that there is sufficient emphasis on skills practice in the programme.
- Time needs to be set aside for AoN test preparation. This is often at the very time that students are preparing for other examinations and finishing their portfolios.
- If you are not a mathematics specialist, you may want to consider ways of improving your own skills in the subject. Colleagues in the mathematics team should be able to provide help and advice, and are likely to have a range of materials and resources that would be useful in supporting your teaching. In particular you will find the LSDA publication *Talking of Number* (ISBN 1 85338 649 9) very helpful (available from the Key Skills Support Programme).

Which model?

There is no definitive answer to this question; each model has its strengths and weaknesses. Successful courses tend to combine the two models, for example by delivering and assessing Application of Number as far as possible within main subjects, but supported by specialist lessons or drop-in provision. (For further guidance on all three models, see Item 3.3 in the *Key skills resource manual*, available from the Key Skills Support Programme.)

Successful courses tend to combine the two models, incorporating the best practice from each.

The pattern of delivery that you adopt will be guided by the needs, strengths and weaknesses in your own institution. A keen mathematician who has an interest in art will be able to make the discrete model work really well with a group of A-level Art and Design students. Similarly, a Business tutor who has studied mathematics to a high level and who already works closely with the mathematics team will be able to overcome the disadvantages of the integrated approach for students on an Intermediate GNVQ in Business.

Whatever model you adopt, help and support will be available if you ask for it. Vocational and subject teachers should seek out friendly mathematicians prepared to advise and share resources; mathematicians should ask to be included in the course team so that they may better understand the students' main course of study. Ask the key skills coordinator to put you in touch with someone who can help. You will find that you are not alone.

Resources

There is a view held, particularly by those who don't actually teach number or mathematics, that the only resources that a mathematics teacher requires are a white board and a marker pen. This is not the case.

The teaching and learning of mathematics and Application of Number require a considerable resource bank – rulers, pencils, drawing instruments, calculators, a variety of textbooks, reference sources, posters for the walls, and so on. The list goes on and on.

You will find a resource checklist in Appendix 2.

Number puzzles

You could try running a weekly number competition with prizes. The problems would need to be thought-provoking, but not impossible. Here are a few possible questions to start things off (the first has been worked through as an example).

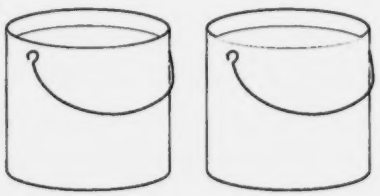
1 The hands of a clock are exactly together at 12.00 noon. Calculate when they will next be *exactly* together.

2 A magic square is a square of numbers in which every row, column, and diagonal add up to the same total, for example:

11	3	10
7	8	9
6	13	5

Set the group the task of making up magic squares. Magic squares in a 4 × 4 arrangement are a real challenge.

3 Fred is mixing paint. He has a pot of white paint and a pot of red paint.



The two pots are the same size as one another. He takes a cupful of red and puts it into the white and stirs it in really well. He then takes a cupful from the mixture and pours it back into the red pot. Is there more red in the white pot or more white in the red pot?

Answers

2 One example of a 4 × 4 grid is:

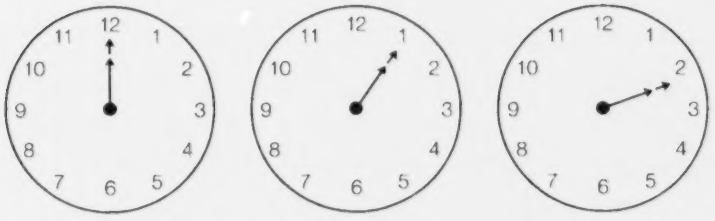
16	2	3	13
5	11	10	8
9	7	6	12
4	14	15	1

3 Both pots end up with exactly the same amount of paint and so however much red has been removed from the red pot, it must have been replaced by an identical amount of white. Think about it! However, most students will try examples (a 1-litre pot, a 100cc cup) ... and after a lot of very worthy calculation will come to the same conclusion.

For more puzzles see some of the websites listed in Appendix 5.

Procedure for question 1

Step 1: **Identify the number of occasions in every 12 hours that the hands will be exactly together.**



It may be helpful to demonstrate this on a watch or clock face. Students' learning styles will influence their ability to visualise this sequence.

Starting at noon, the first occasion is at just after 1:05, the second is a little after 2:10, the third at around 3:17, and so on until the 10th occasion at just before 10:55. The 11th occasion is at midnight, so that is a total of 11 occasions in every 12 hours.

Step 2: **Calculate the time that must elapse between each of the 11 occasions that the hands are exactly together.**

The minute hand takes 60 minutes to go once around the clock face. Therefore, the time that elapses between each occasion is $\frac{60}{11}$ minutes: 5.45 minutes.

Step 3: **Express 0.45 minutes in seconds (= 27 seconds).**

SECTION 3

Where are your students with Application of Number?

Background

Although students of Application of Number are usually taught in groups, it is likely that each student will have a different mathematical background, a different social background and a different set of learning preferences. Consequently, each will have a different set of needs, which teachers have to recognise in order to develop teaching and learning strategies that take account of these differences. Much of AoN teaching time is taken up with filling gaps in students' understanding and skills, and this can create difficulties when teaching the whole group. Whatever strategies are adopted, individual needs should be at the forefront.

The National Curriculum

If your students are all 16 or 17 years old, they will all have followed the National Curriculum in mathematics, even when (as at a college) they will have come from different schools. However, this does not mean that they will all be at the same level of knowledge and ability. The National Curriculum allows for students to progress at different rates, so you can expect a range of attainment levels within your group.

GCSE Mathematics

Grades in GCSE Mathematics may not be the best predictors. For example, the pass mark in the external assessment for a grade C at GCSE Intermediate level is around 50%. Therefore, a student achieving a C may well have failed to answer correctly around half of the questions in the examination. Conversely, a student with a lower grade at GCSE may be more comfortable with the use of numbers in everyday contexts.

Older students

In groups of more mature students, the situation is no different. For these students, superimposed on the mathematical background of school is the mathematics they have faced in everyday life and work. Many will have become accustomed to solving problems using methods that work for them, but that do not appear in any textbook.

Watch your language 1

Number and language are often closely linked especially when a problem is written in a context. Sometimes a student struggles with a problem because of the language that is being used, rather than because they lack the number skills that are required. Setting a similar problem out of context using the numbers alone will help you identify whether this is the case.

Spiky profiles

The profile of a student's mathematical attainment is often referred to as 'spiky'. There are topics that the student understands extremely well, alongside others they find more difficult. The complexity of the topic itself is no guide to this phenomenon; students are often able to solve really challenging problems in one topic and yet have trouble with simple fractions in another.

Don't assume that the methods you were taught at school will be the ones that students will use. There are often a number of different methods for solving the same problem (there are at least four different methods for subtraction alone). Ask your students which methods they were taught and maybe ask one of them to explain the method to the others.

Levels of understanding

There are also different levels of understanding. Students sometimes solve problems by 'muddling through', using techniques that have been learned but not really understood. Somehow, as teachers, we need to differentiate between numerically correct answers achieved through such methods, and numerically correct answers achieved through a good understanding of the technique and the topic. The Application of Number specifications give considerable encouragement to this approach by placing an emphasis on process. A really good understanding improves the transferability of the skills and makes it easier for students to apply the basic techniques in new situations.

Learning styles

Students also come to the Application of Number key skill with a range of learning styles and preferences. Some work best in groups; others work better alone. Some enjoy the challenge of finding out methods for themselves; others work best with clear instructions. Some learn best when the whole-topic overview is presented first so that they can see where each part slots into place; others need a much more sequential approach to the development of a mathematical concept. Some work best with pictorial representation; others prefer words.

If you, the reader, prefer a diagram to a paragraph of text, you will learn more readily from Figure 4 than you will from the preceding paragraph!

Figure 4 Learning styles

groupwork		*individual work*
finding out		*being told*
holistic	*OR*	*sequential*
pictorial		*text*
doing		*listening*
active		*passive*

Learning speed

People learn at different speeds and this can often vary depending on the topic. This is a particular issue in number teaching owing to the hierarchical and sequential nature of the subject referred to in Section 1 (see page 8).

Attitude

It is worth remembering that many students see mathematics as hard. A significant proportion of students will have experienced failure before. However, many students welcome a fresh start, and will display considerable determination to overcome past experiences and succeed this time. This is often especially – but not exclusively – true of adult learners.

So what can I do?

There are a variety of strategies that can take these differences into account. With such a diversity of backgrounds, the first priority is to investigate where each student is starting from.

Initial assessment

Initial assessment is an assessment that helps you and the student to identify the student's appropriate level of study. This process is particularly important in a college setting where the student is often new to the course and to the institution. It usually takes place at interview or at the beginning of the course during induction. In a school, the student and their prior achievements will be known to the teaching staff but it is still helpful to review this in the context of the Application of Number specification.

The best initial assessments:

- identify the level of the student at the time of the assessment
- give an indication of what might be achieved by the end of the year.

Often, initial assessments include an element of self-assessment and can take into account the student's background, such as GCSE results and school reports, although most also include a written or computer-based element. The results allow you to group students into levels or clusters of levels. Although not impossible, running a group with students from Level 1 and Level 3 can be a challenge. Many institutions try to 'set' the Application of Number groups so that all the students in the group are working at roughly the same level. Where this is not possible, it is sometimes helpful to organise the students into Level 1/2 groups and Level 2/3 groups.

Which test to use?

There are many initial assessment tests available, including some from commercial sources. Make sure that you look at a range of tests, ask colleagues in other institutions which ones they use and, if you intend to buy, always ask for inspection copies so that you can pilot the tests before making your choice.

Testing, testing, testing

Students may feel overwhelmed by a barrage of tests at the beginning of the course, particularly if they were not comfortable with mathematics in the past. Try to introduce the assessments with sensitivity and explain that they are not arranged to make students pass or fail but are designed to help them get the best from the course. This is part of the process of encouraging students to take more responsibility for learning and progress. A student who feels ownership of the outcomes of such assessments will be well on the way to success.

Diagnostic assessment

Diagnostic assessment is an assessment that identifies which topic areas the student can deal with well and which are the areas that may need to be worked on further. These tests are usually quite detailed and often take rather longer to work through than the initial assessment. Some diagnostic assessments also include a section on learning styles.

Diagnostic assessment usually takes place at the beginning of the course, although some institutions spread the diagnostic process over the first few weeks. Inevitably, diagnosis – both formal and informal – will continue throughout the course. Remember not to neglect the views of the students themselves; they will often be able to tell you which skills they feel comfortable with, and which need some attention.

These tests provide both you and the student with detailed information, and create a starting point for the individual programme of learning. Collectively, the results of these tests for the group will give you an idea of topic areas that most students can cope with well and, at the other end of the spectrum, topic areas that most students need help with. This will allow you to plan work that makes the best use of time and resources. This process is important for both colleges and schools. We have already seen how a GCSE pass in mathematics may reveal nothing about a student's particular skills, so it is important to carry out a more detailed assessment.

In Section 4 (pages 30–1) we will look at ways of organising groups in the classroom so that individual needs are met while, at the same time, the group and its identity are held together.

Which diagnostic test to use?

As with the initial assessments, diagnostic assessments are available commercially. Many are computer-based, and the best ones will automatically produce an action plan for each student, identifying areas of strength and areas to be worked on. As with initial assessments, you should look at a range of tests, ask colleagues in other institutions which ones they use and always ask for inspection copies to pilot the tests before choosing which to purchase.

These two publications will help you choose a method of initial and diagnostic assessment that is right for you, your students and your institution:

- *Initial assessment of key skills: considerations for schools*
- *Initial assessment of key skills: considerations for colleges*

Both are available from the Key Skills Support Programme.

Other strategies

An effective teacher will deploy a whole range of these strategies in order to maximise learning for everybody. The next section on teaching and learning presents a range of possible strategies that can be employed.

SECTION 4 Teaching and learning

More on the key skills continuum

The Application of Number key skill has much in common with adult numeracy, Mathematics GCSE and Mathematics A-levels, but there are differences. These focus on the word 'application'. All good mathematics teaching involves applying the skills in real life; in Application of Number this is the prime purpose.

The key skills continuum referred to in Section 1 and illustrated on page 9 gives a diagrammatic representation of one model of Application of Number key skills teaching. It shows that there are three stages of skills development:

- stage 1: learning the underpinning skills
- stage 2: developing skills
- stage 3: applying skills.

Each stage requires us to take a different approach in our teaching.

Bizarre numbers

Students can often be enthused by the strange and the outlandish. Problems that are bizarre or amusing can provide useful exercises in number. Here are some examples.

- **How many bananas would be needed to stretch from here to Edinburgh?**
- **How much tarmac is needed to resurface the M1 ?**
- **How many pints of beer would it take to fill this classroom?**

Learning, practising, reinforcing and applying skills

Learning the underpinning skills

The underpinning skills need to be practised in order that they are learnt and become 'second nature' to the students. As is the case when learning any skill, this usually involves some repetition. This practice is best carried out using graduated worksheets, usually out of context. This allows students to practise the skills without a context getting in the way. The external assessment (the test) is itself written to be accessible to everyone and so is not set in any particular vocational or subject context. However, many of the questions (especially at Level 3) focus on everyday situations, such as kitchen design, travel surveys, holiday planning or shopping.

Remember that each student will have different needs, so giving the whole class the same practice sheet will almost certainly not be appropriate. Throughout this section you will find ideas that address this issue. Coping with a mixture of abilities, achievement levels, backgrounds, interests, motivation and attitudes will be a challenge.

Teaching tip

When designing practice worksheets, try to make sure that there are easy questions first, followed by slightly more challenging and complex problems, and ending with a question to challenge the most able student in the group.

Teaching tip

Why not use questions from exemplar tests? These can be cut up and pasted together in topics so that students can practise their skills on questions that are in the same style as the test questions.

Teaching tip: BODMAS

Ask your students to check that their calculators obey the precedence rules (BODMAS).

Write the following problem on the board:

$3 + 4 \times 5$

Ask the students to work it out in their heads first, and then ask what answer they have each arrived at. You are likely to get two answers: 35 and 23.

Point out that both answers are possible, illustrating that it is important to agree a convention that is understood and used consistently so that everyone gets the same answer.

You can then go through the order of precedence rules.

Brackets	*always work out the brackets first*
Order	*powers, as in 2^3*
Division Multiplication	*these should be done in the order given on the page (from left to right)*
Addition Subtraction	*these should be done in the order given on the page (from left to right)*

The students can then check what answers the calculator gives to check whether their own calculators work to the above rules.

Calculators

- Calculators are not allowed in Level 1 and Level 2 external tests.
- Calculators are allowed in Level 3 external tests.
- Students can use calculators for their coursework at all levels.

Levels 1 and 2

Students will need to practise mental as well as pencil-and-paper methods in preparation for the external assessment.

Students can and should be encouraged to use calculators in their portfolio work where this is appropriate. Calculators are an excellent learning tool in number, allowing students to carry out repeated or long-winded calculations effectively and quickly. However, they must learn to distinguish between when to use a calculator and when to use other methods. Students must also learn estimation and checking skills – along with a healthy dose of scepticism – so that they question the answer on the calculator display before writing it down.

Level 3

Examiners' reports have highlighted the problem that many candidates are failing to use their calculators effectively. You will need to teach specific calculator skills, including:

- estimation and checking
- effective use of the memory keys
- use of bracket keys
- understanding the order-of-precedence rules (BODMAS, see page 22) and when to use the '=' key
- standard form.

Experience has shown that these issues are the ones that crop up most frequently, but you may well have others of your own to add to the list.

Calculator notation

Calculators, (especially scientific and graphical calculators) often produce notation that is very different from the notation that we expect to be written on a page. For example: standard form, eg where we write a number such as 30,000 as 3×10^4, is displayed on a calculator as:

3.00000 04 or 3E4

It is important that students understand the various notations and when and where they should be used.

Watch your language 2

The language of number is complicated. How many alternative ways are there of saying 'multiply'? Make sure that you help your students with the language of number as well as with the number skills.

Answer: multiply; times; product; by; times by; dot; nothing at all, as in 'four threes' or '4a'; lots of; of, as in '$\frac{1}{2}$ of 2'; There may well be more!

Watch your language 3

Number problems often start with a 'command word' that reveals what needs to be done with the problem. Words like 'evaluate', 'solve', 'identify' or 'estimate'. How many more can you think of?

Go through the exemplar tests and make a list of all these words. Make sure that your students know what each one is asking them to do.

Developing skills

Once the basic techniques and underpinning skills have been learnt and practised out of context, students need to be able to develop these skills by practising applying them in more practical and concrete situations. To carry this out effectively, students need to engage in short activities and assignments that are a little more open-ended than the practice worksheets. Tasks need to be slightly longer, perhaps involving a stepping-stone approach to solving a problem. These activities work best when they link with the students' main course and areas of interest. Scenarios and case studies can be excellent ways of developing skills in a context that is relevant.

Designing simple skills exercises

Make sure that the exercises you design are each of the following.

- *Relevant*
  Make them as real as you can, worthwhile and relevant to your subject.
- *Simple*
  When you introduce a new number technique, use simple examples to start with so that the calculating ('doing the sums') doesn't get in the way of the number concept that you are trying to teach. Once the students have grasped the concept, you can make the calculations harder.
- *Based on whole numbers*
  A new technique can be absorbed without the problem of decimals or fractions getting in the way. Once the students become confident, they can tackle more difficult situations.
- *Practised*
  Once students have successfully learnt a new numerical technique, you should have plenty of examples available for them to practise on. It is surprising how often students, even those lacking in confidence in number, want to carry on doing the same sort of examples once they are sure they can get it right.
- *Reinforced*
  It is important to keep introducing situations in which students need to apply number. Get them to carry out number work themselves, rather than doing it for them or getting a technician to do it. For example, instead of saying 'you'll need at least a hundred samples to get any meaningful data from that project', say 'how many samples do you think you will need to get meaningful data from that project?'
- *Well presented*
  Clarity and lack of ambiguity are important.

Source: *Talking of Number: A-level and vocational contexts* (LSDA 2001)

Teaching tip

Designing and furnishing a room gives excellent practice in a range of topics, including areas, units, measurement, decimals and percentages. You can easily put it into a context in almost any vocational area by making the room an art studio, a nursery, an office, an engineering workshop or a laboratory.

Teaching tip

If you are trying to find an exercise that helps students practise number skills in context at A-level, ask the students to look at some past examination papers in your subject. Many subjects include an element of data analysis or some calculations. You might want to adapt some of the questions yourself so that the exercise gives a little more practice on the number aspects. In particular, at Level 3, look out for opportunities for students to use large data sets (over 50 items), calculate averages, compare distributions and choose appropriate methods to illustrate findings, show trends and make comparisons.

Applying skills in different contexts

The third stage of the key skills continuum concerns the ability to select and apply the skills and techniques in context, and should always be carried out through activities and assignments in the students' main subjects or vocational area. It is this work that will form the student's portfolio of evidence and so it is important that any assignments set are designed to meet the criteria contained in Part B of the Application of Number key skill specifications. The student should be working as an independent learner at this stage, although the degree to which this happens depends on the key skill level studied (see 'Help, guidance and independence' on page 34).

At this stage, students must be able to demonstrate that they can select the right techniques and use them correctly.

The specifications emphasise the need to adopt a coherent and sequential approach to Application of Number. This is particularly important at Levels 2, 3 and 4, where any piece of work submitted in the portfolio must address all three components of the specifications.

Some ideas for assignments

These ideas are suitable for activities to help students to develop their skills (stage two of the continuum). However, you may want to use some of the ideas to develop longer assignments that meet the criteria for the portfolio.

- *History*
  Whatever the period studied, there are statistics that can be researched and interpreted. For example, if a history group is looking at aspects of Europe in the 1930s, you could set an assignment that compares work patterns in Germany and the UK. Types of employment, gender differences, work hours, unemployment figures could all be studied and compared.
- *Art and Design*
  Life drawing involves reproducing correct body ratios. Did you know that your arm span is generally the same measurement as your height? And did you know that your height is about eight times the height of your head? Students could investigate ratios in the human body by measuring each other and presenting the results in the form of diagrams, tables and charts.
- *Business GNVQ*
  Setting up and running a small business provides lots of opportunities to demonstrate number skills: a survey to establish the market, the establishment of a business plan, running the bank account and presenting end-of-year accounts.
- *Engineering and Design and Technology*
  All Engineering and Design and Technology courses have a practical element that usually involves making a product. In the case of electronics, this may be an electronic gizmo such as a rain detector or a metronome; mechanical engineering students are often asked to produce a machined tool, or a toolbox. These projects provide ample opportunity for demonstrating Application of Number skills for a portfolio: measurements, calculations, costings, presentation of results, diagrams and consideration of errors.
- *Media (GNVQ or GCSE)*
  Compare the use of space in a broadsheet newspaper with that of a tabloid. This will involve categorising articles and adverts, measuring space given to each, presenting findings and highlighting differences and similarities.
- *English*
  Reading-age formulae can be used to investigate the differences between different newspapers, books or even writers. This sort of statistical approach to writing has been used to identify the writer of a newly discovered manuscript (*see* Appendix 5 for website details of some of this research).

The National Statistics website (www.statistics.gov.uk) is a good source of data that can be used in assignment work. It includes data from the censuses, as well as a range of financial and social data on the UK, with excellent 'search' facilities.

Variety in your teaching

The best mathematics teachers use a variety of approaches in their teaching. Each student has a different mathematical background and the group will include students with a variety of learning preferences. There are a lot of topics to cover and a range of skills that need to be practised and learned.

Use different methods to teach different skills. This allows you to vary your activities through a lesson so that interest is maintained and more of the varying needs of individual students are likely to be met.

Teaching tip

Variety is the spice of

Students at Levels 1 and 2 need lots of practice working without calculators, so activities that encourage mental arithmetic skills and quick pencil-and-paper methods are required. Try setting short, quickfire quizzes; they are fun and students do enjoy them! They can also be used to review what the group knows at the beginning of a topic, or as a way of assessing what has been learnt at the end of a lesson or topic.

Tràditional pencil-and-paper methods can be the best way of getting some messages across. At Level 3, for instance, when covering rearranging equations, there really is the need to practise with pencil and paper. It is a bit like music; all the great musicians spend hours practising their scales. There is still a place for this sort of practice in number work – although we shouldn't over use it!

Try using a groupwork exercise to cover volume and area. Set small groups the task of designing packaging for a product (perhaps related to a vocational area). It is surprising just how much of the specification is covered by this exercise (see Appendix 3 for an example). If you get time, go through this task and identify all the skills it covers in Part A of the specifications at Level 2.

Look out for computer programs that could be used for individual topic areas. A good source of information is the *TES* and, in particular, the mathematics curriculum supplement that appears periodically. The Mathematics Association (see Appendix 7) will also be very helpful.

The National Numeracy Strategy suggests that lessons should be broken down into shorter activities. The Strategy suggests that all mathematics lessons should start with a short, active, whole-group starter focusing on oral work and mental calculation. Experience in schools with this approach indicates that this strategy has the effect of kick-starting the lesson and establishing a pace and momentum – a pace that carries through to the rest of the session. It can also be fun!

Teaching tip

Here are two good lesson starter activities that help students to practise pencil-and-paper and mental calculations.

- ***Countup***
  Create your own version of the numbers game from Channel 4's *Countdown*. You could do an impromptu version on the board, making up the numbers yourself, or a full-blown version using cards and a timer. (But you will be without Carol Vorderman and so you will need to be on your toes yourself!)
- ***Bingo***
  Bingo can be used to practise almost any number skill. Try a version where you read out the calculation (eg 2 × 7, 3.2 + 4.6, etc) and the students have to match these with numbers on their bingo cards (14, 7.8, etc). You can extend this to cover equivalents, approximations, algebraic expressions; you will be able to think of lots more examples of your own.
- ***Pairs***
  Produce a set of cards with matching pairs. For instance if you want to practise multiplication, one card will read '6 × 4', while its matching card will read '8 × 3'. The cards are laid out on the desk and each player takes a turn to turn over two cards in an attempt to find a matching pair. Like the Bingo activity, this can be adapted to a variety of topics. For instance, you could match decimals with fractions, imperial with metric measures, or pair algebraic identities.

Active learning

I hear and I forget
I see and I remember
I do and I understand

Confucius (551–479 BC)

Most people learn best by doing. As you can see from the quotation, this has been known for a very long time. What is surprising, therefore, is that this principle is so often disregarded by both teachers and learners. Always be on the lookout for ways in which your lessons can become more active.

- Where students need to read something, get them to paraphrase what is said, make a poster or explain what they have learnt to a peer.
- Instead of telling students something, get them to find it out for themselves.
- Instead of using a written problem to calculate an area or volume, get them to do the problem for real.
- Ask a student to 'teach' a point, or even a short topic, for revision.
- Encourage discussion in the classroom; use groupwork as well as individual work to promote this.

All these ideas will lead to real activities (with the emphasis on 'active'), which are more likely to lead to a deeper understanding of number and its concepts.

Ah, but it will take up too much time!

Time is always an issue. There is never enough. However, rushing through the specifications with fewer and fewer students keeping up, and never giving time for concepts to be assimilated and to become part of the student's thinking, is a really poor use of time. There should always be time to teach something well. Good methods encourage self-reliance and autonomy in learning and, as the students become better learners, their pace of learning will increase and you may well find that these methods are rather more time-efficient than they appear at first sight.

Differentiation of levels

This term covers a whole raft of strategies that can be used to help you to accommodate differences in your teaching group. Some of them are outlined here.

Graduated tasks

Set activities that start with short, easy, closed tasks that get progressively harder, longer and more open-ended. Students will then work through the activities and, if they are well designed, there will be a challenge for everyone. For example, in a Level 2 Construction GNVQ group, if the topic is 'fractions conversions', the first questions will be dealing with easy fractions, for example $\frac{1}{2}$, $\frac{1}{4}$. Later questions should deal with more challenging fractions, for example $\frac{3}{7}$. The final questions might include some written problems set in context, or an open-ended task, producing a number-line poster, related to the construction industry, with different fractions clearly marked.

Choice

Offer a selection of tasks to the group so that students can choose one that interests them and is at a level that will challenge them but is not out of their reach. Students will sometimes need some guidance in making the choice. Many topics in number can be studied at a range of levels. It is therefore possible to teach a short introduction to the whole class and then present different worksheets set at different levels, or even with different contexts, to suit the variety of interests across the group. This would allow you to deal effectively with a mixed group made up of students from two vocational areas, or a number of different A-levels.

Differentiated resources

A well-resourced number classroom will have a whole variety of resources (see Appendix 2 for a list of suggestions). If you have a good indexing system, students can seek out resources and help that are appropriate for them. If you have a computer in the classroom, there are various learning packages that could be used in this way.

Extension tasks

Always try to have available a task that is demanding – one that would challenge the most able in the group. Some of the best extension tasks are open-ended. Don't worry if you are not sure of the answer yourself; there will be people in your institution that can help and, in some cases, there may not be a definitive answer anyway. Mathematics teaching has sometimes been criticised for not paying enough attention to the most able students. This strategy is one way of addressing the problem.

Question and answer

Try directing questions to particular students. General questions to the group usually get answered by the quickest, most able, or sometimes the most vociferous students. By selecting individuals and asking questions that are at an appropriate level for those individuals, you will challenge more of the group more of the time.

Another good question-and-answer strategy is to present the question and ask everyone to write down the answer. This also allows individuals in the group to think through their response themselves rather than have the question answered immediately by someone else.

Groupwork

Using groupwork is one strategy that can help to overcome lack of confidence. Working individually can be rather daunting for some students. A group can be a safer environment for many. It is usually wise for you to keep some control of the mix in each group, although you may feel that, for some classes, self-selecting groups may work equally well. Groups can be good for students who need support – other group members will take on some responsibility for explaining tasks and topics. It is also good for the more able members of the group. There is a lot of truth in the adage that you don't know that you understand something properly until you have taught it.

Groupwork is particularly useful when the students have learnt the underpinning skills and are starting to develop them in context (see 'Developing skills' in Section 4, page 24).

Responding to errors

When a student makes a mistake in a calculation, teachers might simply mark it wrong and perhaps offer a correct solution. However, in doing so, we may be missing a golden opportunity to gain an insight into how the student is thinking and how we can best help put things right.

Some general points:

- errors are often the result of misconceptions rather than careless slips
- you need to diagnose the misconception rather than simply re-teach the topic
- an effective strategy is to ask the student to explain or record how they worked out the answer...
- ...then deal with the misconception, perhaps by offering a different explanation, or by using a different resource to model the method
- try to be proactive about addressing misconceptions
- the students themselves can identify many problems by systematically checking their answers.

You will find a list of some common errors, together with examples of each, in Appendix 4.

SECTION 5 Assessment

There are two components to the formal assessment of the Application of Number key skill.

- *The portfolio*
  This contains the evidence specified in Part B of the unit.
- *The external test*
  This assesses the student's competence in the underpinning knowledge and skills specified in Part A of the unit.

Hints and tips on the AoN portfolios

Summative portfolio assessment requires evidence that a student can apply number purposefully in real contexts. For example, at Level 2 students must provide evidence that they can independently:

- select information and methods to get the results that they need
- carry out calculations and check methods and levels of accuracy
- select ways to present findings, describe methods and explain results.

Further help on portfolios or assignment writing is available in the *Good practice guides: developing and managing portfolios* and *writing assignments*. Both are available from the Key Skills Support Programme.

This requires students to show a degree of autonomy. So how can you help them to produce portfolios that meet the required standard?

You need to:

- be familiar with the current activities and processes in the subject or vocational area
- be able to identify the opportunities for applying number in these activities and processes
- base assignment briefs on purposeful, realistic and relevant activities and processes
- create summative assessment activities that allow students to work independently, selecting and using number techniques in real contexts.

Your assignment briefs should:

- be focused on real, up-to-date situations
- include number activities as an integral and purposeful part of the tasks
- provide opportunities for students to select and use number techniques independently (see 'Help, guidance and independence' on page 34)
- cover all the evidence requirements in Part B of the specifications.

To meet these requirements, you may need to look for some additional training or do a little research, but, if you get stuck, there will be colleagues in your own centre who will be able to help. It is comforting to know that, if you are grappling with a problem, there will be colleagues in exactly the same position in other centres, and many will have found appropriate solutions. Contact the Key Skills Helpline (see Appendix 7) to get details of local networks where you can meet other key skills practitioners.

Help, guidance and independence

You will need to walk a fine line when helping students to build their portfolios. The specifications expect students to take more responsibility as they progress up the levels, so it is important that any help and guidance you give does not prevent the student from demonstrating the autonomy required. For example, at Level 2 the specifications require students to 'select effective ways to present findings'. If, in helping a student, you tell them to draw a pie chart, then you are giving too much help.

It is usually safest to answer questions with a question. For example: 'What aspect of the data do you want to highlight here?' or 'What graph or chart do you think would be best to use to do this?'

Preparing students for the Application of Number tests

At Levels 1 and 2, the external assessment of the Application of Number key skill is a multiple-choice test. At Levels 3 and 4, it is a written test comprising some short and some longer answers.

The key skills tests at Levels 1 and 2 in Application of Number are the same tests as those for adult numeracy at these levels. Figure 2 on page 5 shows the links between the standards of Application of Number, adult numeracy and the National Curriculum Descriptors for Mathematics.

Further guidance on preparing students for the key skills tests can be found in the *Good practice guide: preparing for external assessment*, available from the Key Skills Support Programme.

Additional information on exactly what will be tested and how it will be tested at each level is available on the QCA website, www.qca.org.uk/nq/ks

The best preparation for the external tests at all levels is through the teaching and learning of the underpinning skills in Part A, and through being aware of the links between the levels, specifications, standards and curricula. You should not base test preparation solely on exemplar tests (available from the QCA website), as each of these will illustrate only the range of what can be tested. However, to ensure that your students are confident about sitting the tests and have the best possible chance of passing, you will find it useful to cover each of the following areas.

- Developing time-management skills.
- Tackling multiple-choice questions (Levels 1 and 2 only). In particular, encourage students to:

  go through the paper tackling all the easy questions first, and leaving the trickier ones until later; this allows them to gain confidence, as well as ensuring they have time in hand

  always rule out the impossible options first so that, if it comes to a guess later on, the probability of getting the right answer is improved

  make sure that they answer all the questions – there is no penalty for an incorrect answer.
- Linking the length and depth of the answer they give to the number of marks available (Levels 3 and 4 only).
- What to do about questions they don't understand or find difficult. This will involve teaching some problem-solving techniques (for some ideas on this, see *Talking of Number*, available from the Key Skills Support Programme). This is also linked to developing time-management skills; if a question remains unsolved after the allotted time, it is always best to leave it and, time permitting, return to it later, towards the end of the exam.

You should not base test preparation solely on exemplar tests.

Some strategies to improve students' test techniques

- Use quizzes and games to test underpinning skills.
- Provide timed-test practice, initially using only parts of papers.
- Read chief examiners' reports (available from awarding bodies) and focus your preparation on the areas identified as the most problematic.
- Encourage self- and peer-marking of answers. Students are usually their own harshest critics.
- If you can't get enough past papers or exemplars, write your own questions using the test guidance on the QCA website.
- Get the students to attempt to write some questions themselves, either individually or in pairs, and then use the questions to test each other. This helps to demystify the process and will make them realise that there is actually a fairly limited number of possible question types for each topic.

Keep the tests in proportion, in relation to your approach to the Application of Number key skill. The tests are there to corroborate the portfolio evidence, so reassure your students that, if they have learned and practised the underpinning skills, they will be able to pass the test.

Appendix 1

Application of Number Part A

In this grid, each level assumes knowledge of the previous level.

For a glossary, see Appendix 6.

Level 1	Level 2	Level 3
In interpreting information, you need to know how to:	**In interpreting information,** you need to know how to:	**In planning an activity and interpreting information,** you need to know how to:
		plan a substantial and complex activity by breaking it down into a series of tasks
	obtain relevant information from different sources (eg from handwritten and graphical material), first hand by measuring or observing	obtain relevant information from different sources including a large data set (over 50 items), and use this to meet the purpose of the activity
read and understand straightforward tables, charts, diagrams and line graphs	read and understand graphs, tables, charts and diagrams (eg frequency diagrams)	read and understand scale drawings, graphs, complex tables and charts
read and understand numbers used in different ways (eg large numbers in figures or words, simple fractions, decimals, percentages)	read and understand numbers used in different ways, including negative numbers (eg for losses in trading, low temperatures)	read and understand ways of writing very large and very small numbers (eg £1.5 billion, 2.4×10^{-3})
	estimate amounts and proportions	use estimation to help you plan, multiplying and dividing numbers of any size rounded to one significant figure;
measure in everyday units (eg minutes, millimetres, litres, grams, degrees) by reading scales on familiar measuring equipment (eg watch, tape measure, measuring jug, weighing scales, thermometer)	read scales on a range of equipment to given levels of accuracy (eg to the nearest 10mm or nearest inch)	understand and use compound measures (eg speed in kph, pressure in psi, concentrations in ppm)
make accurate observations (eg count number of people or items)	make accurate observations (eg count number of customers per hour)	make accurate and reliable observations over time and use suitable equipment to measure in a variety of appropriate units
identify suitable calculations to get the results you need for your task	select appropriate methods for obtaining the results you need, including grouping data when this is appropriate (eg heights, salary bands)	choose appropriate methods for obtaining the results you need and justify your choice

Level 1	Level 2	Level 3
In carrying out calculations, you need to know how to:	**In carrying out calculations,** you need to know how to:	**In carrying out calculations,** you need to know how to:
work to the level of accuracy you have been told to use (eg round to the nearest whole unit, nearest 10, two decimal places)	show clearly your methods of carrying out calculations and give the level of accuracy of your results	show your methods clearly and work to appropriate levels of accuracy
add, subtract, multiply and divide with whole numbers and simple decimals (eg two decimal places)	carry out calculations involving two or more steps, with numbers of any size	carry out multi-stage calculations with numbers of any size (eg find the results of growth at 8% over 3 years, find the volume of water in a swimming pool)
		use powers and roots (eg work out interest on £5000 at 5% over 3 years)
understand and find simple fractions and percentages (eg $\frac{2}{3}$ of £15 is £10, 75% of 400 is 300)	convert between fractions, decimals and percentages	
	convert measurements between systems (eg from pounds to kilograms, between currencies)	
work out areas of rectangular spaces (eg floor areas); work out volumes of rectangular-based shapes (eg a box)	work out areas and volumes (eg area of an L-shaped room, number of containers to fill a given space)	
		work out missing angles and sides in right-angled triangles from known sides and angles
use ratio and proportion (eg three parts to one part)	use proportion and calculate using ratios where appropriate	work out proportional change (eg add VAT at 17.5% by multiplying by 1.175)
use straightforward scales on diagrams (eg 10mm to 1 m)	work out dimensions from scale drawings (eg using a 1:20 scale)	work out actual measurements from scale drawings (eg room or site plan, map, workshop drawing) and scale quantities up and down
find the average (mean) of up to 10 items (eg temperature, prices, time); find the range for up to 10 items (eg temperature range from highest to lowest was 16°C)	compare sets of data with a minimum of 20 items (eg using percentages, using mean, median, mode); use range to describe the spread within sets of data	work with large data sets (over 50 items), using measures of average and range to compare distributions, and estimate mean, median and range of grouped data
	understand and use given formulae (eg for calculating volumes, areas such as circles, insurance premiums, V=IR for electricity)	rearrange and use formulae, equations and expressions (eg formulae in spreadsheets, finance and area and volume calculations)
check calculations using different methods (eg estimate to reject impossible answers, check a subtraction by 'adding back') to make sure they make sense	check your methods in ways that pick up faults and make sure your results make sense	use checking procedures to identify errors in methods and results

continued.../

Level 1	Level 2	Level 3
In interpreting results and presenting your findings, you need to know how to:	**In interpreting results and presenting your findings,** you need to know how to:	**In planning an activity and interpreting information,** you need to know how to:
	select effective ways to present your findings	select and use appropriate methods to illustrate findings, show trends and make comparisons
use the correct units (eg for area, volume, weight, time, temperature)		
label your work correctly (eg use a title or key)		
		examine critically, and justify, your choice of methods
use suitable ways of presenting information including a chart and diagram	construct and use graphs, charts and diagrams (eg pie charts, frequency tables, workshop drawings), and follow accepted conventions for labelling these (eg appropriate scales and axes)	construct and label charts, graphs, diagrams and scale drawings using accepted conventions
	highlight the main points of your findings and describe your methods	draw appropriate conclusions based on your findings, including how possible sources of error might have affected your results
describe how the results of your calculations meet the purpose of your task	explain how the results of calculations meet the purpose of your activity	explain how your results relate to the purpose of your activity

Appendix 2

Resources for teaching number

This list is not intended to be exhaustive, nor is it an unattainable wish list. It is intended as a list of ideas, indicating some of the resources that are available. If you are a mathematics specialist, you will already have most of this equipment. If you are not, this gives an idea of what is available. Ask a friendly mathematician; many of the items on the list may already be in your institution.

- Simple calculators (for Levels 1 and 2)
- Scientific calculators (for Level 3)
- Rulers
- Protractors
- Compasses
- Pencils
- Pens
- Glue
- String
- Tracing paper
- Graph paper
- Squared paper
- Dotty-pattern paper for number pattern work and perspective drawings
- Metre rules
- White-board drawing instruments
- A calculator with OHP display facilities
- A balance (for algebra work, to model equations)
- Scales for weighing
- Dice
- At least one computer. There are lots of mathematics teaching programs available. For ideas, look in the *TES* (especially when there is a mathematics curriculum supplement), ask the head of mathematics to show you catalogues, and look at the NANAMIC and Mathematical Association websites (see Appendix 5).
- A video player
- Solid shapes (pyramid, sphere, cuboid, tetrahedron, etc)
- Trundle wheel (for measuring long distances)
- Tape measures
- Worksheets (to give practice across a series of topics)
- A variety of textbooks. The KSSP website (www.keyskillssupport.net) offers a resources index that provides information on what is available and a short review of each resource, written by a practitioner.
- Posters. These should always be purposeful. Posters showing the application of number are especially good, eg where numbers are used in particular jobs.
- Student work displays
- A multiplication square (see page 37 of the adult numeracy core curriculum for more information.)
- A fraction wall, showing fraction equivalents (see page 39 of the adult numeracy core curriculum for more information.)

The adult numeracy core curriculum is available from the Basic Skills Agency.

Appendix 3

Task sheet: designing packaging

Equipment needed

- Card
- Glue stick
- Sticky tape
- Rulers
- Pencils
- Drawing instruments
- Small, 'travel' shampoo bottles

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1 Divide into groups of three or four.

The shampoo bottle provided is being adopted by *Flashotel*, an expensive and exclusive chain of hotels. The management thinks that the presentation will be greatly improved if the bottles were to be boxed in a carton bearing the hotel logo. The final design will be chosen using the following criteria:

presentation
cost
ease of manufacture
imagination and innovation.

2 Design and make three alternative cartons for the shampoo bottle provided.

3 For each carton, find:

the area of card used
the volume of the carton.

4 Choose the carton that you think is the best.

5 Prepare a 3-minute presentation for the whole group explaining why your group's carton is the best.

If you get time...

6 The boxes will be cut from sheets of card that are 100cm long by 100cm wide. Work out how many boxes you can cut from one sheet of card. (This is not as easy at it may first seem!)

7 Your tutor has been asked by the management to make the final choice of carton – and there will be a prize!

Appendix 4

Common calculation difficulties

Some common errors and examples

1 Obvious computational error or careless slip

Correct operation but incorrect recall of basic number facts.

Example: A pencil costs 37p and a ballpoint pen costs 45p. How much would eight pencils and three ballpoint pens cost together?

Answer:
$$\begin{array}{rl} 8 \times 37 = & 303 \\ 3 \times 45 = & 135 \; + \\ \hline & 438 \end{array}$$

2 Conceptual error

Student has not grasped the concept of the relevant operation.

Example: Calculate the value of 5^7

Answer: 10

3 Misunderstanding of vocabulary

Example: Estimate the value of 28.93×20.987

Student's answer: 607.15391

Correct estimate: $29 \times 21 = 609$

4 Wrong operation

The wrong operation is used in the solution.

Example: Find 15% of £300

Answer: $\frac{300}{15} \times 100 =$ £2000

5 Defective procedure or method

Correct operation chosen and no number fact errors, but errors in carrying out steps of the procedure.

Example: There are 12 boys and 18 girls in a key skills class. What percentage of the whole class is made up of boys?

Answer: $\frac{12}{30} \times 100 = 250\%$

6 Incorrect transfer of a rule

Pattern or rules learned and then applied to situations where they no longer work.

Example: The rule that has been learned is: 'to multiply by 10, add a nought'. What is 3.1×10?

Answer: 3.10

7 Over-generalisation

The student is led to generalise on the basis of too little information.

Example: 2, 4, 8... What is the next number?

Answer: 16 (The answer could be 16, but it might equally be 14.)

8 Random response

A wild guess!

Example: A coach has been hired for a college trip. It costs £600 for the day. If there are 50 students on the trip, how much should each student pay?

Answer: £31.24

Appendix 5

Mathematics and number websites

For imaginative and interesting ideas try:

- www.counton.org
- www.schoolzone.co.uk
- www.nrich.maths.org

The BBC has a range of excellent materials and activities for teaching and learning:

- www.bbc.co.uk/schools/revision/index.shtml
- www.bbc.co.uk/education/numberwork
- www.bbc.co.uk/education/megamaths

The *Guardian* has a site that has lots of interactive revision material for students at a range of levels:

- www.learn.co.uk

The DfES has a site that is designed to support the numeracy strategy and includes lots of ideas, lesson plans, programs and self-study materials:

- www.standards.dfee.gov.uk/numeracy

For some puzzles:

- freespace.virgin.net/anthony.edey/homepage.htm

Analysing language (see page 27)

Some information on the statistical investigation of work by Shakespeare:

- www.theatlantic.com/unbound/flashbks/shakes/dolnick.htm
- www.pbs.org/newshour/bb/entertainment/shake_1-15.html

Appendix 6

Glossary

Accuracy
In Application of Number, the requirements for accuracy vary between the levels. For details, see *The key skills qualifications specifications and guidance* (Level 1, page 45; Level 2, page 50; Level 3, page 56).

Evidence of checking for accuracy is required at all levels. At Levels 1–3, 'where there is a series of calculations of the same type, evidence of checking at least the first few of each type should be recorded for assessment purposes. For the remainder, accurate results should confirm that effective checking has taken place.' (*The key skills qualifications specifications and guidance*, pages 45, 50, 56)

Adult literacy and numeracy
QCA defines adult literacy and adult numeracy skills as 'the ability to read, write and speak in English and to use mathematics at a level necessary to function at work and in society in general.' (*The key skills qualifications specifications and guidance*, page 3) The key skills tests at Levels 1 and 2 in Communication and Application of Number also act as the tests for adult literacy and numeracy. Candidates who gain the adult literacy and numeracy certificates by passing these tests can progress to achieving the full key skills qualifications. In order to meet the requirements of the internal assessment component of the key skills qualifications, candidates would have to develop a suitable portfolio of evidence.

Advanced
Advanced-level qualifications are at Level 3 of the National Qualifications Framework and include AS levels, A-levels, Vocational A-levels, NVQs at Level 3 and key skills at Level 3.

Assessment
(a) Formative assessment This is part of the feedback that a teacher provides during a learning programme to help the candidate reflect on and review their progress. QCA has begun to refer to 'assessment for learning' rather than 'formative assessment'. It has no direct effect on the student's final result.

(b) Summative assessment This is the assessment – which may be in stages during a course, or all at the end – that determines whether a candidate has achieved the qualification and, if appropriate, with what grade.

Assessor
The person responsible for the initial judgment of a candidate's performance against standards that have been defined by the awarding body. These standards are normally expressed as assessment criteria or mark schemes.

Awarding body
There are 18 awarding bodies offering key skills qualifications, including the Unitary Awarding Bodies in England (Edexcel, OCR, AQA), WJEC in Wales and CCEA in Northern Ireland. They are all listed on the QCA website.

Basic skills
Literacy and numeracy provision that caters for the literacy, language (ESOL) and numeracy needs of all post-16 learners, including those with learning difficulties or disabilities, from pre-entry level up to and including Level 2. This includes all forms of provision, whether delivered as stand-alone, or as part of a vocational programme or bolt-on course, and whether delivered full-time, part-time or through self-study or information and communications technology (ICT).

Charts
QCA defines charts as 'representations of frequency data' (*The key skills qualifications specifications and guidance*, page 42). Examples are: pie chart or bar chart, histogram, pictogram, frequency polygon, frequency chart or diagram.

Complex
Complex subjects and materials present a number of ideas, some of which may be abstract, very detailed or require candidates to deal with sensitive issues. A complex subject may require candidates to deal with the relationship of ideas and lines of enquiry dependent on clear reasoning, where these relationships may not be immediately clear. The subject matter must be challenging to the candidate. Specialised vocabulary and complicated sentence structures may be used (*The key skills qualifications specifications and guidance*, page 19). In Communication Level 3, the candidate must provide two different types of document about complex subjects (*The key skills qualifications specifications and guidance*, page 37).

Diagrams
QCA defines diagrams as any graphical method of representation other than a chart or graph, where scale is or is not a factor (*The key skills qualifications specifications and guidance*, page 42). Examples include: scale drawing, plan or workshop drawing, circuit drawing, 3-D representation, flowchart, critical path or network diagram, and organisation chart.

External assessment
In the key skills qualifications, the tests are the external assessment and corroborate the internal assessment. The test questions sample from the whole specification. The tests are externally set, are taken under supervised conditions and are externally marked (*The key skills qualifications specifications and guidance*, page 10).

Fitness for purpose
Key skills portfolio evidence should be appropriate for the context and purpose for which it was produced.

Foundation
Foundation-level qualifications are at Level 1 of the National Qualifications Framework and include GCSEs at grades D–G, Foundation GNVQs, NVQs at Level 1 and key skills at Level 1.

Grade
There are no grades for key skills.

Graph
QCA defines graphs as representations based on points located in a coordinate system using *x* and *y* axes. Examples include single or multiple line graphs and scatter graphs with or without line of best fit (*The key skills qualifications specifications and guidance*, page 42).

Intermediate
Intermediate-level qualifications are at Level 2 of the National Qualifications Framework and include GCSEs at grades A*-C, Intermediate GNVQs, NVQs at Level 2 and key skills at Level 2.

Internal assessment
Internal assessment of key skills is internally organised, focuses on the requirements of Part B of the specifications, is based on a portfolio of evidence and is internally assessed and externally moderated (*The key skills qualifications specifications and guidance*, page 10).

Internal verification
This is the process through which an identified person in a centre ensures that the standards of assessment in the centre are consistent both across the centre and with national standards. Key skills internal verifiers do not require particular qualifications but should be competent at the level of key skill that they are verifying. The awarding bodies offer training for internal verifiers. An internal verifier is often referred to as an 'IV'.

Key Skills Qualification
The key skills of Communication, Application of Number and IT are each a qualification in their own right. From September 2000 to July 2001, there was also a Key Skills Qualification, which was made up of these three key skills. This is being phased out. Candidates already registered for the Key Skills Qualification must complete by August 2004.

Moderation
The process through which internal assessment is monitored by an awarding body to ensure that it is valid, reliable, fair and consistent with the required national standards. Each centre will be allocated a standards moderator for key skills. This role is sometimes referred to as an external verifier.

National Qualifications Framework
The NQF was created by the 1997 Education Act and includes all external qualifications that are regulated by QCA (ACCAC in Wales and CCEA in Northern Ireland), plus degrees and other higher-level qualifications which are regulated by the universities and QAA.

Portfolio
Candidates have to organise and present evidence of how they have met the requirements of the specifications, usually in a portfolio. This may take the form of a file or may be an electronically based storage-and-retrieval system (*The key skills qualifications specifications and guidance*, page 18).

Purposeful
Key skills evidence must be generated in the context of a task or activity that satisfies some purpose in the student's work or leisure. Evidence that is collected simply to satisfy the requirements of the key skills portfolio is not purposeful and does not meet the assessment requirement.

Specification
The complete description – including mandatory and optional aspects – of the content, the assessment arrangements and the performance requirements for a qualification. In the past, this has often been referred to as a 'syllabus'.

Straightforward
Straightforward subjects and materials are those that the student often meets in work, studies or other activities. The main points are easy to identify, usually with simple sentences and familiar vocabulary (*The key skills qualifications specifications and guidance*, page 19).

Substantial activity
An activity that includes a number of related tasks, where the results of one task will affect the carrying out of others. For example, in Application of Number, a substantial activity will involve obtaining and interpreting information, using this information when carrying out calculations and explaining how the results of the calculations meet the purpose of the activity (*The key skills qualifications specifications and guidance*, page 19).

Tests
Assessment of the key skills qualifications includes a written test (see 'External assessment' on page 44). Details can be found on the QCA website. There are no tests for the wider key skills.

Transferable
Key skills are transferable. This simply means that, once a student has developed a skill for the purpose of one context, they should be able to identify when and how to apply the same skill for another purpose in another context.

Note

The key skills qualifications specifications and guidance: Communication, Application of Number and Information Technology: Level 1–4 (2002) is published by QCA. It amalgamates the following three publications:

- *Guidance on the key skills units: Levels 1–3 in Communication, Application of Number and Information Technology*
- *Guidance on the key skills units: Level 4 in Communication, Application of Number and Information Technology*
- *Addendum – Guidance on the key skills units in Communication, Application of Number and Information Technology*

Copies can be ordered from:

QCA Publications
PO Box 99
Sudbury
Suffolk CO10 2SN
Tel 01787 884444
Fax 01787 312950

Price: £10.00

Order ref: QCA/02/896

Appendix 7

Useful addresses

ACCAC (Qualifications, Curriculum and Assessment Authority for Wales)
Castle Buildings
Womanby Street
Cardiff CF10 1SX
Tel 029 2037 5400
www.ccw.org.uk

AQA (Assessment and Qualifications Alliance)
Devas Street
Manchester M15 6EX
Tel 0161 953 1180
Publications 0161 953 1170
www.aqa.org.uk

ASDAN (Award Scheme Development and Accreditation Network)
Wainbrook House
Hudds Vale Road
St George
Bristol BS5 7HY
Tel 0117 941 1126
Publications 0117 941 1448
www.asdan.co.uk

BSA (Basic Skills Agency)
Commonwealth House
1–19 New Oxford Street
London WC1A 1NU
Tel 020 7405 4017
www.basic-skills.co.uk

CCEA (Northern Ireland Council for the Curriculum, Examinations and Assessment)
Clarendon Dock
29 Clarendon Road
Belfast BT1 3BG
Tel 028 9026 1200
Publications 028 9026 1228
www.ccea.org.uk

City & Guilds
1 Giltspur Street
London EC1A 9DD
Tel 020 7294 2468
www.city-and-guilds.co.uk

DfES (Department for Education and Skills)
Key Skills Policy Team
Room E3c
Moorfoot
Sheffield S1 4PQ
Tel 0114 259 4944
Publications 0845 602 2260
www.dfes.gov.uk/keyskills

Edexcel
Stewart House
32 Russell Square
London WC1B 5DN
Tel 0870 240 9800
Publications 01623 467467
www.edexcel.org.uk

Key Skills Support Programme (LSDA)
Regent Arcade House
19–25 Argyll Street
London W1F 7LS
Key Skills Helpline 0870 872 8081
kssp@LSDA.org.uk
www.keyskillssupport.net

Key Skills Support Programme (Learning for Work)
6 Hemdean Road
Caversham
Reading RG4 7SX
Helpline 0118 947 2000
www.keyskillssupport.net

LSC (Learning and Skills Council)
Cheylesmore House
Quinton Road
Coventry CV1 2WT
Tel 0845 019 4170
www.lsc.gov.uk

LSDA (Learning and Skills Development Agency)
Regent Arcade House
19–25 Argyll Street
London W1F 7LS
Information Services 020 7297 9144
enquiries@LSDA.org.uk
www.LSDA.org.uk

Mathematical Association
259 London Road
Leicester
LE2 3BE
Tel 0116 221 0013
www.m-a.org.uk/index.html

NANAMIC (National Association for Numeracy and Mathematics in Colleges)
www.nanamic.org.uk

OCR (Oxford Cambridge and RSA Examinations)
Coventry Office
Westwood Way
Coventry CV4 8JQ
Tel 02476 470033
Publications 0870 8706 622
www.ocr.org.uk

Ofsted
Alexandra House
33 Kingsway
London WC2B 6SE
Tel 020 7421 6800
Publications 0700 263 7833
www.ofsted.gov.uk

QCA (Qualifications and Curriculum Authority)
83 Piccadilly
London W1J 8QA
Tel 020 7509 5555
Publications 01787 884444
www.qca.org.uk/keyskills

UCAS (Universities and Colleges Admissions Service)
Rosehill
New Barn Lane
Cheltenham GL52 3LZ
Tel 01242 222444
Publications 01242 544903
www.ucas.ac.uk

The Key Skills Support Programme

This support programme for post-16 schools and colleges is funded by the Department for Education and Skills and the European Union Social Fund. The Programme provides teachers, lecturers and managers with information, advice, materials and training. The priorities of the Programme are to:

- raise awareness and understanding of key skills
- provide practical advice, solutions, exemplars and models
- produce materials on teaching and learning key skills
- provide training in the form of conferences, workshops, courses and regional training.

A dedicated Key Skills Helpline is available on 0870 872 8081 every weekday to answer questions on key skills and provide information updates. The website on www.keyskillssupport.net provides news and information on key skills developments, resources, publications, frequently asked questions, training and network activities, contacts and links. Newsletters are published on a termly basis and are sent to all post-16 schools and colleges in England.

Research on key skills development and delivery is undertaken through development projects and action research in schools and colleges.

There are links with the awarding bodies and with the parallel support programme for trainers in work-based learning, managed by Learning for Work (tel 0118 947 2000).

How to find out more

You can contact the **Key Skills Helpline Tel 0870 872 8081 kssp@LSDA.org.uk www.keyskillssupport.net**

or the **Key Skills Support Programme team**:

Deirdre Kimbell
executive manager
Tel 020 7297 9053
dkimbell@LSDA.org.uk

Judy Carrick
development adviser – training taskforce
Tel 020 7297 9050
jcarrick@LSDA.org.uk

Sylvia Gentleman
development adviser – ILT and website
Tel 020 7297 9049
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Tel 020 7297 9052
pwhite@LSDA.org.uk

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Tel 020 7297 9047
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development adviser – Dysg, Learning and Skills Development Agency for Wales
Tel 029 2074 1819
cmorgan@LSDA.org.uk

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